Claims

[c1] 1.A method for equalizing a storage parameter for a vehicle energy storage system having one or more energy storage banks associated therewith, the method comprising:
identifying a quiescent period of operation for the vehicle;
determining whether the value of a defined storage quantity for a first energy storage bank differs from the value of said defined storage quantity for a second energy storage bank by a threshold amount; and
during said quiescent period of operation, discharging one of said first and second energy storage banks and charging the other of said first and second energy storage banks;
wherein said one of said first and second energy storage banks corresponds to the bank having the value of said defined storage quantity exceeding the value of said defined storage quantity of said other of said first and second energy storage banks.

[c2] 2.The method of claim 1, wherein said defined storage quantity comprises at least one of: stored energy, rela-

tive stored energy, stored energy minus rating, stored charge, relative stored charge, and stored charge minus rating.

[c3] 3.A method for equalizing a storage parameter for a vehicle energy storage system having one or more energy storage banks associated therewith, the method comprising:
identifying an active period of operation for the vehicle;
determining whether the value of a defined storage quantity for a first energy storage bank differs from the value of said defined storage quantity for a second energy storage bank by a threshold amount;
during a motoring operation of the vehicle, applying discharging energy from said one of said first and second energy storage banks to said motoring operation if the value of said defined storage quantity for said one of said first and second energy storage banks differs from the value of said defined storage quantity for said other of said first and second energy storage banks by said threshold amount.

[c4] 4.The method of claim 3, further comprising:
during a dynamic braking operation of the vehicle, applying charging energy generated by dynamic braking operation to said other of said first and second energy storage banks if the value of said defined storage quan-

tity for said one of said first and second energy storage banks differs from the value of said defined storage quantity for said other of said first and second energy storage banks by said threshold amount.

[c5] 5.A method for resetting a state of charge (SOC) calculation for a designated energy storage bank of an energy storage system of a vehicle, the method comprising:
during operation of the vehicle, completely discharging and completely charging the designated energy storage bank;
maintaining the designated energy storage bank at a predetermimed high terminal voltage for a specified period of time; and
following said specified period of time, defining a calculated, reset SOC for the designated energy storage bank to be a known SOC capacity.

[c6] 6.The method of claim 5, wherein said completely discharging the designated energy storage bank further comprises discharging energy from the designated energy storage bank to at least one of: one or more available energy storage banks in the energy storage system, a vehicle motoring operation, and a resistive grid.

[c7] 7.The method of claim 6, wherein:
said one or more available energy storage banks are a

preferred discharging sink for the designated energy storage bank over said vehicle motoring operation and said resistive grid; and
said vehicle motoring operation is a preferred discharging sink for the designated energy storage bank over said resistive grid.

[c8] 8.The method of claim 5, wherein said completely charging the designated energy storage bank further comprises supplying charging energy to the designated energy storage bank from at least one of: one or more available energy storage banks in the energy storage system, a vehicle dynamic braking operation, and a combustion engine of the vehicle.

[c9] 9.The method of claim 8, wherein:
said one or more available energy storage banks are a preferred charging source for the designated energy storage bank over said vehicle dynamic braking operation and said combustion engine; and
said vehicle dynamic braking operation is a preferred charging source for the designated energy storage bank over said combustion engine.

[c10] 10.A method for generating an energy storage control parameter for a vehicle energy storage system, the method comprising:

determining energy storage heat generation information;
determining energy storage coolant flow information; and
estimating, from said energy storage heat generation information and said energy storage coolant flow information, a storage bank temperature.

[c11] 11.The method of claim 10, wherein said determining energy storage heat generation information further comprises calculating storage bank power dissipation information from at least one of: an energy storage power dissipation measurement, an energy storage current measurement, an energy storage power command signal, and an energy storage current command signal.

[c12] 12.The method of claim 10, wherein said determining energy storage heat generation information further comprises receiving at least one temperature measurement upstream from battery storage cells included within the energy storage system, and receiving at least one temperature measurement downstream from said battery storage cells.

[c13] 13.The method of claim 10, wherein said determining energy storage coolant flow information further comprises receiving at least one of: a coolant flow measurement, a coolant fan speed, a coolant pump speed, a fan

terminal power value, a fan terminal current value, a fan supply frequency, a fan voltage value, a pump terminal power value, a pump terminal current value, a pump supply frequency, and a pump voltage value.

[c14] 14.The method of claim 10, wherein said estimating a storage bank temperature further comprises receiving one or more actual temperature measurements within the vehicle energy storage system.

[c15] 15.The method of claim 10, wherein said estimating a storage bank temperature further comprises utilizing at least one of: an energy storage cell thermal resistance value, an energy storage cell heat capacity value, an energy storage module thermal resistance value, an energy storage module heat capacity value, an energy storage assembly thermal resistance value, and an energy storage assembly heat capacity value.

[c16] 16.The method of claim 10, wherein said storage bank temperature comprises a battery temperature.

[c17] 17.The method of claim 17, wherein said energy storage coolant flow information comprises airflow information.

[c18] 18.A method for generating an energy storage control parameter for a vehicle energy storage system, the method comprising:

receiving energy storage electrical property information; and

estimating, from said energy storage electrical property information, a storage bank temperature.

[c19] 19.The method of claim 18, wherein said energy storage electrical property information includes at least one of: internal resistance, change in internal resistance, equivalent series resistance, terminal voltage, and open circuit recovery time constant.

[c20] 20.The method of claim 18, wherein said estimating a storage bank temperature further comprises receiving one or more actual temperature measurements within the vehicle energy storage system.

[c21] 21.The method of claim 18, wherein said estimating a storage bank temperature further comprises utilizing at least one of: a battery cell thermal resistance value, a battery cell heat capacity value, a battery module thermal resistance value, a battery module heat capacity value, a battery assembly thermal resistance value, and a battery assembly heat capacity value.

[c22] 22.A method for controlling a dynamic discharge rate for one or more energy storage banks in a vehicle energy storage system, the method comprising:

determining a charging/discharging rate of each energy storage bank within the energy storage system; and adjusting a calculated capacity value for each said energy storage bank, based upon said determined charging/discharging rate, so as to produce a modified capacity; wherein said modified capacity for each said energy storage bank is used in one or more energy storage system control algorithms.

[c23] 23.The method of claim 21, further comprising:
obtaining a charging/discharging signal from each said energy storage bank; and
filtering each said charging/discharging signal to produce a filtered charging/discharging rate signal;
wherein said filtered charging/discharging signal is used to produce said modified capacity.

[c24] 24.A method for controlling the operating range of one or more energy storage banks in a vehicle energy storage system, the method comprising:
determining a point at which the energy storage bank has reached a threshold value with respect to an end of life (EOL) condition; and
responsive to said threshold value, reducing at least one of an energy storage bank operating parameter and an energy storage bank operating range.

[c25] 25.The method of claim 24, wherein the energy storage bank further comprises a storage battery and said at least one energy storage bank operating parameter and said at least one energy storage bank operating range further comprises at least one of: a charging terminal voltage, a maximum state of charge (SOC), a maximum current flow, a maximum power flow, a maximum stored energy, an operating range between minimum and maximum SOC, an operating range between minimum and maximum stored energy, an operating range between minimum and maximum stored charge, an operating range between minimum and maximum terminal voltage.

[c26] 26.The method of claim 25, wherein said threshold value with respect to an end of life (EOL) condition is based upon at least one of: a total number of ampere-hours charged or discharged, a total number of kilowatt-hours charged or discharged, a total number of operating hours in charge or discharge mode, an elapsed time in operation, a number of vehicle missions completed, a total vehicle distance traveled, a vehicle total fuel consumed or energy supplied from an engine, an increase in calculated battery internal resistance or impedance, or reduction of charge or energy used to equalize a state of charge (SOC) calculation of said battery.

[c27] 27.A method for controlling one or more energy storage banks in a vehicle energy storage system, the method comprising:
determining a remaining life cycle for each of the energy storage banks; and
allocating a total amount of commanded charging and discharging power commanded among each of the energy storage banks in accordance with said determined remaining life cycle thereof.

[c28] 28.The method of claim 27, wherein power flow is prioritized in accordance with the one or more energy storage banks having the highest remaining life cycle.

[c29] 29.The method of claim 27, further comprising:
determining an initial participation factor for each of the energy storage banks, said initial participation factor representing the relative contribution of a given storage bank with respect to the remaining storage banks;
wherein said initial participation factor for each energy storage bank is determined based upon at least one of: a power rating thereof, an energy rating thereof, a calculated state of charge (SOC) thereof, and stored energy information thereof.

[c30] 30.The method of claim 29, further comprising:
determining a remaining life cycle for each of the energy

storage banks; and
based on said determined remaining life cycle for each of the energy storage banks, generating an adjusted participation factor for one or more of the energy storage banks;
wherein an initial participation factor for a first storage bank having a greater remaining life cycle is increased with respect to an initial participation factor for a second storage bank having a lesser remaining life cycle.

[c31] 31.A method for characterizing and projecting remaining cycle life for vehicle storage battery, the method comprising:
performing a series of initial battery characterization tests;
performing a series of periodic battery tests during the operating life of the vehicle storage battery;
comparing the results of said periodic battery tests with said initial battery characterization tests; and
projecting a remaining cycle life for the vehicle storage battery.

[c32] 32.The method of claim 31, wherein said series of initial battery characterization tests further comprises:
a first test, said first test comprising an initial commissioning charge and capacity test;
a second test, said second test comprising a full

recharge and partial discharge test; and
a third test, said third test comprising a partial charge and partial discharge test.

[c33] 33.The method of claim 32, further comprising adding water to the vehicle storage battery following completion of said first test, if the water level thereof is below a minimum defined level.

[c34] 34.The method of claim 32, wherein during the performance of said third test, if an output voltage of the storage battery drops to a first cut-off value, then said third test is aborted and said first test is repeated.

[c35] 35.The method of claim 34, wherein during the performance of said third test, if an output voltage of the storage battery drops to a second cut-off value, then said third test is aborted and said first test is repeated.

[c36] 36.The method of claim 35, wherein said first cut-off value is related to a determined level of discharge current spiking associated with said third test, and said second cut-off value is related to a final C rate discharge portion associated with said third test.

[c37] 37.The method of claim 36, further comprising:
repeating said third test for a least a first number, N_1 of iterations, wherein N_1 represents a specified number of

cycles between an initial commissioning charge and a scheduled maintenance of the storage battery; and following at least N_1 iterations of said third test, continuing subsequent iterations of said third test until a battery output quantity falls below a corresponding rated quantity of the storage battery, at which time a second number, N_2 of total iterations is recorded.

[c38] 38.The method of claim 37, wherein said rated quantity of the storage battery corresponds to one of: a percentage of rated power, and a percentage of rated energy.

[c39] 39.The method of claim 38, wherein said series of periodic battery tests further comprises said first test, said second test and said third test.